US006430434B1

(12) **United States Patent**
Mittelstadt

(10) **Patent No.: US 6,430,434 B1**
(45) **Date of Patent: Aug. 6, 2002**

(54) **METHOD FOR DETERMINING THE LOCATION AND ORIENTATION OF A BONE FOR COMPUTER-ASSISTED ORTHOPEDIC PROCEDURES USING INTRAOPERATIVELY ATTACHED MARKERS**

(75) Inventor: **Brent D. Mittelstadt**, Placerville, CA (US)

(73) Assignee: **Integrated Surgical Systems, Inc.**, Davis, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/458,358**

(22) Filed: **Dec. 9, 1999**

Related U.S. Application Data

(60) Provisional application No. 60/112,321, filed on Dec. 14, 1998.

(51) **Int. Cl.**[7] **A61B 5/103**

(52) **U.S. Cl.** **600/426**; 600/429; 606/130

(58) **Field of Search** 600/411, 414, 600/417, 426, 427, 429; 606/130; 128/922, 920

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,146,924	A	3/1979	Birk et al.
4,373,532	A	2/1983	Hill et al.
4,841,975	A	6/1989	Woolson
4,932,414	A	6/1990	Coleman et al.
4,945,914	A	8/1990	Allen
4,991,579	A	2/1991	Allen
5,016,639	A	5/1991	Allen
5,086,401	A	2/1992	Glassman et al.
5,094,241	A	3/1992	Allen
5,097,839	A	3/1992	Allen
5,119,817	A	6/1992	Allen
5,142,930	A	9/1992	Allen et al.
5,161,536	A	11/1992	Vilkomerson et al.
5,167,165	A	12/1992	Brucher et al.
5,178,164	A	1/1993	Allen
5,180,382	A	1/1993	Frigg et al.

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

EP	647428		12/1995	
WO	WO 91/07726		5/1991	
WO	WO 94/17733		8/1994	
WO	WO 96 11624	*	4/1996	..... 600/426
WO	WO 97/09929		3/1997	

OTHER PUBLICATIONS

Cain, et al., "Safety considerations in a surgical robot", Integrated Surgical Systems, Inc., Sacramento, California, Paper #93–035, pp. 291–294, (1993).

Kazanzides, et al., "Surgical and industrial robots: Comparison and case study", Integrated Surgical Systems, Inc., Sacramento, California, vol. 10, pp. 10–19 to 10–26 (circa 1994).

Kazanzides, et al., "Architecture of a surgical robot", IEEE Conference on Systems, Man, and Cybernetics, pp. 1624–1629, (1992).

(List continued on next page.)

Primary Examiner—Ruth S. Smith
(74) *Attorney, Agent, or Firm*—Townsend and Townsend and Crew LLP

(57) **ABSTRACT**

A method for re-registration between a robotic coordinate system and an image data set, said method comprising: providing an image data set that has been registered within a robotic coordinate system based upon an initial bone position within the robotic coordinate system; locating at least three conserved points fixed relative to the initial bone position prior to any detectable change in bone position from the initial bone position; relocating the same three conserved point after bone motion may have occurred to determine the locational change in the three conserved points; and re-register the image data set within the robotic coordinate system based on the locational changes.

5 Claims, 5 Drawing Sheets